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[Title of the Invention] Vehicle-installed Display Device and Portable Display Device

[*Claims*]

[Claim 1]

A vehicle-installed display device, comprising:

a vehicle motion detecting means configured to detect movements of the vehicle;

a display means configured to display an image;

a displayed image displacement computing means configured to compute a translational displacement of an image displayed by the display means using information that indicates a movement of the vehicle detected by the vehicle motion detecting means; and

a display control means configured to make the display means display images in such a manner as to cancel the translational displacement computed by the displayed image displacement computing means.

[Claim 2]

A vehicle-installed display device, comprising

a vehicle motion detecting means configured to detect movements of the vehicle;

a motion value determining means configured to determine a motion value related to a

movement of the head or an eye of a passenger by actually detecting the movement of the head or eye of the passenger or by estimating the movement of the head or eye of the passenger;

a display means configured to display an image;

a displayed image displacement computing means configured to compute a translational displacement of an image displayed by the display means using information that indicates a movement of the vehicle detected by the vehicle motion detecting means;

a relative displacement computing means configured to compute the relative displacement between said displayed image and the head or eye of the passenger based on information indicating the translational displacement computed by the displayed image displacement computing means and the motion value related to a movement of the head or an eye of the passenger determined by the motion value determining means; and

a display control means configured to make the display means display images in such a manner as to cancel said translational displacement and said relative displacement.

[Claim 3]

The vehicle-installed display device as recited in claim 2, wherein

the motion value determining means determines the motion value using a response function expressing the vibration of a human body in response to the undulations of a

vehicle or using a numerical model.

[Claim 4]

The vehicle-installed display device recited in claim 3, wherein

the motion value determining means determines the motion value using the physique and sitting posture of the passenger as estimated parameters.

[Claim 5]

The vehicle-installed display device recited in claim 3, wherein

the motion value determining means estimates the sitting posture and physique of the passenger based on the distribution of body pressure on the seat on which the passenger is sitting and selects a response function expressing said human body vibration or a numerical model based on the estimated sitting posture and physique.

[Claim 6]

A portable display device, comprising

a display means configured to display an image;

a motion detecting means configured to detect movements of the display ;

a displayed image displacement computing means configured to compute a translational

displacement of an image displayed by the display means using information that indicates a movement of the display means detected by the motion detecting means; and

a display control means configured to make the display means display images in such a manner as to cancel the translational displacement computed by the displayed image displacement computing means.

[Claim 7]

A vehicle-installed display device, comprising:

a vehicle motion detecting means configured to detect movements of the vehicle;

a display means configured to display an image;

a displayed image displacement computing means configured to compute a translational displacement of an image displayed by the display means using information that indicates a movement of the vehicle detected by the vehicle motion detecting means; and

a display control means configured to make the display means display images in such a manner as to cancel the translational displacement computed by the displayed image displacement computing means, wherein

there is further provided a center deviation computing means that computes the deviation between the center of the displayed image and the center of the display area of the display

means and

the display control means further makes the display means display images in such a manner as to cancel said center deviation.

[Claim 8]

The vehicle-installed display device as recited in claim 7, wherein

the center deviation computing means uses the average position of the centers of a plurality of displayed images displayed on the display means within a prescribed amount of time as said center of the displayed image and repeats the center deviation computation not faster than once every three seconds.

[Claim 9]

The vehicle-installed display device as recited in claim 7 or 8, wherein

there is further provided an acceleration/deceleration operation determining means that determines if an acceleration or deceleration operation is being executed with respect to the vehicle; and

the center deviation computing means stops computation of the center deviation when the acceleration/deceleration operation determining means determines that an acceleration or deceleration operation is being executed and executes computation of the center deviation when the acceleration/deceleration operation determining means determines that an

acceleration or deceleration operation is not being executed.

[Claim 10]

The vehicle-installed display device as recited in claim 9, wherein

The acceleration/deceleration operation determining means determines if an acceleration or deceleration operation is being executed by detecting at least one of the following: pedal operation, steering operation, and vehicle motion.

[*Detailed Description of the Invention*]

[0001]

[TECHNICAL FIELD TO WHICH THE INVENTION BELONGS]

The present invention relates to a vehicle-installed display device that displays images inside a vehicle and to a portable-type display device.

[0002]

[PRIOR ART]

Regarding display devices that display images, there are known technologies for preventing a viewer from experience a feeling that something is abnormal when the viewer moves. Patent Document 1 discloses a display device that has a Fresnel lens or other optical element arranged between the display device and the viewer. The Fresnel lens causes the viewer to see a virtual image projected to a position close to infinity. When the viewer views from below a normal line of the Fresnel lens, the projected image is seen above the normal line and when the viewer views from above a normal line, the projected image is seen below the normal line.

[0003]

Patent Document 2 discloses a display device that is fixed to the head of the viewer. This display device causes the image to appear stationary to the viewer by scrolling the displayed image oppositely to the movement of the viewer's head when the viewer's head moves.

[0004]

[Patent Document 1]

Japanese Laid-Open Patent Publication No. 10-73785

[Patent Document 2]

Japanese Laid-Open Patent Publication No. 8-220470

[0005]

[OBJECTS THE INVENTION IS TO ACHIEVE]

With the technology of Patent Document 1, it is difficult to reduce the size of the display in a case, for example, where the display is installed inside a vehicle because an optical element is disposed between the viewer and the display and it is necessary to secure space for the optical path of the optical element. Meanwhile, the technology of Patent Document 2 is not well-suited to situations in which an image is viewed on a display device that is installed inside a vehicle or a display device that is held in the hand of the viewer because said technology requires the display device to be fastened to the viewer's head.

[0006]

The object of the present invention is to provide a vehicle-installed display device and portable display device that do not cause the viewer to experience a feeling that something is abnormal when the relative positions of the display device and the viewer

fluctuate.

[0007]

[MEANS OF ACHIEVING THE OBJECT]

A vehicle-installed display device in accordance with the present invention detects movements of the vehicle, computes the translational displacement of the displayed image based on the detected information, and displays the image in such a manner as to cancel the displacement.

A vehicle-installed display device in accordance with the present invention determines a motion value related to the head (eye) of a passenger by either actually detecting or estimating a movement of the head (eye) of the passenger, computes the translational displacement of a displayed image based on the detected vehicle movement, and – based on information indicating the translational displacement and the motion value related to the head (eye) of the passenger – displays the image in such a manner as to cancel the displacement of the displayed image and the relative displacement between the head (eye) of the passenger and the displayed image.

A portable display device in accordance with the present invention detects movements of the display means, computes the translational displacement of the displayed image based on the detected information, and displays the image in such a manner as to cancel the displacement.

A vehicle-installed display device in accordance with the present invention displays an image in such a manner as to cancel the translational displacement of the displayed image

computed using information obtained by detecting movements of the vehicle and, additionally, displays the image in such a manner as to cancel the deviation between the center of the displayed image and the center of the display area of the display means.

[0008]

[EFFECTS OF THE INVENTION]

The present invention computes the translational displacement of an image displayed by a display means, computes the relative displacement between the head of a viewer (passenger) and a and the displayed image, and makes the display means display the image in such a manner as to cancel the computed displacement (relative displacement). Thus, the present invention makes it possible to prevent a passenger viewing a displayed image from experiencing a feeling that something is abnormal when the relative positions of the display means and the head of the viewer fluctuate.

[0009]

[EMBODIMENTS OF THE INVENTION]

Embodiments of the present invention will now be described with reference to the drawings.

(First Embodiment)

Figure 1 is a block diagram outlining a vehicle-installed display device in accordance with a first embodiment of the present invention. In Figure 1, the vehicle-installed display device 100 has a vehicle motion detecting section 101, a passenger motion estimating section 104, a seat surface pressure detecting section 102, a human body database section 103, a control section 106, an image input section 105, an image displacement section 107, and an image display section 108. The viewer sits on a seat

(not shown in the figures) inside a vehicle and views an image displayed on the image display section 108.

[0010]

The vehicle motion detection section 101 detects both the translational motion and the rotational motion of the vehicle and sends detection signals to the passenger motion estimating section 104 and the control section 106. The seat surface pressure detecting section 102 detects the distribution of body pressure on the seat on which the viewer (in this case, a passenger of the vehicle) is sitting and sends a detection signal to the passenger motion estimating section 104. The human body database section 103 stores data indicating the relationship between the body pressure distribution and the physique of the passenger, data indicating the relationship between the body pressure distribution and the sitting posture of the passenger, and data indicating vibration transmission functions for various parts of the human body (particularly the head) in relation to vehicle undulations. The stored data is obtained in advance from measurements related to a plurality test subjects having different physiques and stored in a database form. The vehicle undulations are indicated by the vehicle motion detection values.

[0011]

Using the detection values indicating the vehicle motion and the detection value indicating the body pressure distribution, the passenger motion estimating section 104 reads information indicating the head motion of a person having a physique and posture similar to those of the passenger from the human body database section 103 and estimates the motion (displacement) of the passenger's head section, particular the eyes. The passenger motion estimating section 104 then sends information indicating the estimated displacement of the passenger's eyes to the control section 106.

[0012]

The image input section 105 receives display data from an external device and sends the display data to the image displacement section 107. The display data is data for an image or text to be displayed on the image display section 108. The control section 106 determines the amount of displacement of the image using the information indicating the estimated displacement of the passenger's eyes and the detection signal indicating the vehicle motion. In addition to determining the amount of image displacement, the control section 106 is configured to control the other sections of the vehicle-installed display device 100. The control section 106 sends information indicating the amount of image displacement determined by the control section 106 to the image displacement section 107. Based on the information indicating the amount of image displacement, the image displacement section 107 modifies the display data in such a manner that the position of the image (including text) moves (shifts) within the display screen of the image display section 108. Image shifting is discussed in more detail later.

[0013]

After modification, the display data is sent to the image display section 108 as a display signal adapted to the input interface of the image display section 108. The image display section 108 is, for example, a liquid crystal display device and displays images (including text) in accordance with the inputted display signal.

[0014]

The present invention serves to make the image displayed on the image display section 108 appear stationary in space to the passenger, even when the vehicle is accelerating or decelerating. In the first embodiment, the relative displacement between the head (particularly the eyes) of the passenger and the image display section 108 is calculated

and the image (including text) on the display screen of the image display section 108 is moved in accordance with the relative displacement. The motion of the passenger's head is estimated using the body pressure distribution detected when the passenger sits.

[0015]

The flow of the display processing executed by the control section 106 of the vehicle display device 100 will now be described with reference to the flowchart of Figure 2. In step S10, the control section 106 determines if the power to the screen of the image display section 108 is ON. If the screen power is ON, the control section 106 obtains an affirmative result for step S10 and proceeds to step S20. If the screen power is not ON, the control section obtains a negative result for step S10 and repeats step S10.

[0016]

In step S20, the control section 106 issues a command to the seat surface pressure detecting section 102 instructing the same to detect the distribution of body pressure on the seat on which the passenger is sitting (body pressure measurement) and then proceeds to step S30. In step S30, the control section 106 issues a command to the passenger motion estimating section 104 instructing the same to estimate the physique and posture of the passenger and then proceeds to step S40. In response to this command, the passenger motion estimating section 104 searches the human body database and selects the physique and posture corresponding to the body pressure distribution that is closest to the detected body pressure distribution as the estimate values for the physique and posture of the passenger.

[0017]

In step S40, the control section 106 issues a command to the vehicle motion detecting section 101 instructing the same to detect the motion of the vehicle (motion

measurement) and then proceeds to step S50. In responds to the command, the vehicle motion detecting section 101 detects the translational motion and rotational motion of the vehicle. In step S50, the control section 106 determines if the passenger's posture has changed. The control section 106 compares the previous posture estimate value to the current posture estimate value and proceeds to step S60 (obtains affirmative result for step S50) if the two estimate values are different and proceeds to step S70 (obtains negative result for step S50) if the two estimate values are the same.

[0018]

In step S60, the control section 106 issues a command to the passenger motion estimating section 104 instructing the same to select a human body vibration transmission function and then proceeds to step S70. In response to the command, the passenger motion estimating section 104 searches the human body database and selects a human body vibration transmission function corresponding to the currently estimated physique and posture of the passenger and the latest detection values for the vehicle motion.

[0019]

In step S70, the control section 106 issues a command to the passenger motion estimating section 104 instructing the same to estimate the motion of the passenger's head and then proceeds to step S80. In response to the command, the passenger motion estimating section 104 calculates an estimate value for the motion of the passenger's head (particularly the eyes) using the human body vibration transmission function and the vehicle motion detection values. In step S80, the control section 106 uses the detection signal indicating the vehicle motion to calculate the amount of translational screen movement associated with rotational motion of the vehicle and then proceeds to step S90. The screen movement calculated here is the amount by which the image display section

108 moves in the pitch direction (up or down).

[0020]

In step S90, the control section 106 calculates the relative displacement between the eyes of the passenger and the image display section 108 and then proceeds to step S100. In step S100, the control section 106 uses the vertical movement amount of the screen and the aforementioned relative displacement to calculate the amount by which the image displayed by the image display section 108 needs to be displaced in order to appear stationary in space (without undulations) to the passenger. Then the control section proceeds to step S110.

[0021]

In step S110, the control section 106 sends information indicating the calculated amount of image displacement to the image displacement section 107 and issues a command instructing the same to shift the image. In response to this command, the image displacement section 107 modifies the display data received through the image input section 105 in accordance with said displacement amount. Meanwhile, the control section 106 proceeds to step S120.

[0022]

In step S120, the control section 106 issues a command to the image display section 108 instructing the same to display the image described by the modified display data and then proceeds to step S130. As a result, an image that has been moved within the screen is displayed on the image display section 108. In step S130, the control section 106 determines if the power to the screen of the image display section 108 has been turned OFF. If the screen power has been turned OFF, the control section obtains an affirmative result for step S130 and ends the processing of Figure 2. Meanwhile, if the screen power

has not been turned OFF, the control section 106 obtains a negative result for step S130 and returns to step S20 to repeat the processing.

[0023]

The details of the image shifting will now be described. Focusing on motion in the pitch direction accompanying acceleration or deceleration of the vehicle, the displacement of relative positions of the passenger's eyes and the image display section 108 can be roughly divided into the following two types:

(1) Displacement caused by pitch motion of the vehicle

(2) Displacement caused by pitch motion of the passenger (particularly the eyes)

[0024]

The displacement type (1) will now be described with reference to Figure 3 (a). Generally, when a vehicle decelerates, a nosedive phenomenon occurs in which the front section of the vehicle dips downward. If the display screen of the image display section 108 is located in the direction of vehicle movement with respect to the passenger, the nosedive will cause the image display section 108 to undergo rotational motion in the pitch direction (downward). Consequently, assuming the position of the passenger's head (particularly the eyes) does not move, the image display device 108 will appear (to the passenger) to move downward. Therefore, the control section 106 modifies the display data in order to displace the display position of the image in the pitch direction (upward), thus canceling out the movement of the image display section 108.

[0025]

Figure 3 (b) illustrates the image shift executed in order to cancel the pitch motion of the vehicle when the vehicle nosedives. As shown in Figure 3 (b), the image displayed on the

image display section 108 is moved upward in accordance with the amount by which the image display section 108 moves downward. As a result, the relative displacement between the displayed image and the eyes of the passenger is zero and the displayed image appears stationary in space to the passenger.

[0026]

Conversely to when the vehicle decelerates, when the vehicle accelerates a squatting phenomenon occurs in which the rear section of the vehicle dips downward. If the display screen of the image display section 108 is located in the direction of vehicle movement with respect to the passenger, the squatting will cause the image display section 108 to undergo rotational motion in the pitch direction (upward). Consequently, assuming the position of the passenger's head (particularly the eyes) does not move, the image display device 108 will appear (to the passenger) to move upward. Therefore, the control section 106 modifies the display data in order to displace the display position of the image in the pitch direction (downward), thus canceling out the movement of the image display section 108.

[0027]

Figure 3 (c) illustrates the image shift executed in order to cancel the pitch motion of the vehicle when the vehicle squats. As shown in Figure 3 (c), the image displayed on the image display section 108 is moved upward in accordance with the amount by which the image display section 108 moves downward. As a result, the relative displacement between the displayed image and the eyes of the passenger is zero and the displayed image appears stationary in space to the passenger.

[0028]

The displacement type (2) will now be described with reference to Figure 4 (a). When the

vehicle actually decelerates or accelerates, the passenger's head also undergoes rotational motion in the pitch direction. As shown in Figure 4 (a), the passenger's head rotates forward when the vehicle decelerates and, assuming the position of the image display section 108 does not move, the position of the passenger's head (particularly the eyes) moves downward with respect to the image display section 108. Therefore, in order to display the image such that it appears stationary in space to the passenger, the image displayed on the image display section 108 is moved downward in accordance with the amount of downward movement of the passenger's eyes, as shown in Figure 4 (b). Thus, the direction of the image shift is the same as in Figure 3 (c), i.e., the same as when canceling the vehicle pitch motion associated with squatting.

[0029]

Conversely to when the vehicle decelerates, the passenger's head rotates rearward when the vehicle accelerates and, assuming the position of the image display section 108 does not move, the position of the passenger's head (particularly the eyes) moves upward with respect to the image display section 108. Therefore, in order to display the image such that it appears stationary in space to the passenger, the image displayed on the image display section 108 is moved upward in accordance with the amount of upward movement of the passenger's eyes. Thus, the direction of the image shift is the same as in Figure 3 (b), i.e., the same as when canceling the vehicle pitch motion associated with nose-diving.

[0030]

In the first embodiment, the relative displacement between the image display section 108 and the eyes of the passenger is found and image shifting is performed in accordance with the relative displacement. As a result, the image is shifted in such a manner as to cancel

the influences of both types of pitch motion, i.e., (1) and (2).

[0031]

The following operational effects are obtained with the first embodiment described heretofore.

(1) The physique and sitting posture of the passenger is estimated by measuring the pressure exerted by the body of the passenger when seated and searching a human body database 103. As a result, an appropriate human body vibration transmission function can be selected regardless of whether the passenger is an adult or a child or a man or a woman.

[0032]

(2) Since the human body vibration transmission function mentioned in (1) above and detection data indicating the vehicle motion are used to calculate an estimate value for the motion of the passenger's head (particularly the eyes), the position of the passenger's eyes can be obtained without providing motion detection sensors on the passenger's head. Since sensors are not attached to the passenger, the cost is held in check and a burden is not placed on the passenger.

[0033]

(3) Since the amount by which the image display section 108 moves in the pitch direction (up or down) due to rotational motion of the vehicle is calculated using detection data that indicates the vehicle motion, the position of the image display section 108 can be obtained without providing a motion detection sensor for the image display section 108.

[0034]

(4) Since the relative displacement between the eyes of the passenger and the image display section 108 is found using the eye position mentioned in (2) above and the position of the image display section mentioned in (3) above, said relative displacement

can be obtained even if the two are undergoing different motions.

[0035]

(5) The displayed image appears stationary in space to the passenger because the display position of the image (including text) displayed on the image display section 108 is moved (shifted) in the pitch direction in such a manner as to cancel the movement of the displayed image resulting from movement in the pitch direction (up or down) of the image display section 108 and changes in the relative displacement mentioned in (4) above. As a result, the image is easier for the passenger to view. Furthermore, since the visual information the passenger obtains when watching the display screen matches the information from the vestibular organs (semicircular canals and otolith organs), the feeling that something is abnormal is reduced in comparison with a case in which the image is not shifted.

[0036]

Additionally, when there is plenty of distance between the image display means 8 and the passenger, the processing of step S70 can be skipped because the motion (displacement) of the passenger's eyes due to rotation of the passenger's head is small. In such a case, it is sufficient to find the relative displacement between the passenger's eyes and the image display section 108 under the assumption that position of the passenger's eyes is fixed.

[0037]

The human body database section 103 of the first embodiment is configured to store data that indicates transmission functions that serve as information regarding how the various body parts (particularly the head) vibrate in response to vehicle undulations. It is also acceptable to store a numerical model in table form. More specifically, a LUT (look up table) can be constructed such that when a value indicating the undulations of the vehicle

is inputted to the LUT, a value indicating the vibrations of the human body in response to those undulations is outputted from the LUT.

[0038]

Although the preceding explanation used rotational motion in the pitch direction as an example, similar processing can be performed with respect to rotational motion in the rolling direction (left and right) of the vehicle.

[0039]

(Second Embodiment)

Figure 5 is a block diagram outlining a vehicle-installed display device in accordance with a second embodiment of the present invention. In Figure 5, the vehicle-installed display device 200 has a vehicle motion detecting section 201, a head motion estimating section 202, a screen vibration detecting section 203, a control section 205, an image input section 204, an image displacement section 206, and an image display section 207. The viewer views an image displayed on the image display section 207 inside a vehicle.

[0040]

The vehicle motion detecting section 201 detects both the translational motion and the rotational motion of the vehicle and sends a detection signal to the control section 205. The head motion detecting section 202 comprises, for example, an acceleration sensor built into a headphone and functions to detect both the translational motion and the rotational motion of the viewer's head (here, the head of a passenger in a vehicle) and send the resulting detection signal to the control section 205.

[0041]

The screen vibration detecting section 203 detects the translational motion of the image display section 207 and the rotational motion of the image display section 207 and sends

the resulting detection signal to the control section 205. The image input section 204 receives display data from an external device and sends the display data to the image displacement section 206. The control section 205 determines the amount of displacement of the image the detection signal indicating the vehicle motion, the detection signal indicating the head motion, and the detection signal indicating the motion of the image display section 207. In addition to determining the amount of image displacement, the control section 205 is configured to control the other sections of the vehicle-installed display device 200. The control section 205 sends information indicating the amount of image displacement determined by the control section 205 to the image displacement section 206. Based on the information indicating the amount of image displacement, the image displacement section 107 modifies the display data in such a manner that the position of the image moves (shifts) within the display screen of the image display section 207. The image shifting is the same as in the first embodiment.

[0042]

After modification, the display data is sent to the image display section 207 as a display signal. The image display section 207 is, for example, a liquid crystal display device and displays images in accordance with the inputted display signal.

[0043]

In the second embodiment, the motion of the passenger's head (particularly the eyes) is detected directly by the head motion detecting section 202 and the motion of the image display section 207 is detected directly by the screen vibration detecting section 203.

[0044]

The flow of the display processing executed by the control section 205 of the vehicle display device 200 will now be described with reference to the flowchart of Figure 6. In

step S210, the control section 205 determines if the power to the screen of the image display section 207 is ON. If the screen power is ON, the control section 205 obtains an affirmative result for step S210 and proceeds to step S220. If the screen power is not ON, the control section obtains a negative result for step S210 and repeats step S210.

[0045]

In step S220, the control section 205 issues a command to the vehicle motion detecting section 201 instructing the same to detect the motion of the vehicle (motion measurement) and then proceeds to step S230. In response to the command, the vehicle motion detecting section 201 detects the translational motion and rotational motion of the vehicle. In step S230, the control section 205 issues a command to the screen vibration detecting section 203 instructing the same to detect the motion of the image display section 207 and then proceeds to step S240. In response to the command, the screen vibration detecting section 203 detects the translational motion and rotational motion of the image display section 207.

[0046]

In step S240, the control section 205 issues a command to the head motion detecting section 202 instructing the same to detect the motion of the passenger's head and then proceeds to step S250. In response to the command, the head motion detecting section 202 detects the translational motion and rotational motion of the passenger's head (particularly the eyes). In step S250, the control section 205 uses the detection signal indicating the vehicle motion to calculate the amount of translational motion of the screen resulting from rotational motion of the vehicle and then proceeds to step S260. This screen movement amount is the amount of movement of the image display section 207 in both the pitch direction (up and down) and the roll direction (left and right).

[0047]

In step S260, the control section 205 calculates the relative displacement between the vehicle and the eyes of the passenger using the aforementioned detection values and the proceeds to step S270. In step S270, the control section 205 calculates the relative displacement between the vehicle and the image display section 207 using the aforementioned detection values and proceeds to step S280. In step S280, the control section 205 uses the screen movement amount and the relative displacements just mentioned to calculate the displayed image displacement amount required to make the image displayed by the image display section 207 appear stationary in space (without undulations) to the passenger. A separate image displacement amount is calculated for each of the up-and-down direction and the left-and-right direction. The controller proceeds to step S290.

[0048]

In step S290, the control section 205 sends information indicating the calculated displacement amounts to the image displacement section 206 and issues a command instructing the same to shift the image. In response to the command, the image displacement section 206 modifies the display data received from the image input section 204 in accordance with the displacement amounts. The control section proceeds to step S300.

[0049]

In step S300, the control section 205 issues a command to the image display section 207 instructing the same to display the image described by the modified display data and then proceeds to step S310. In response to the command, the image display section 207 displays an image that has been moved within the screen. In step S310, the control

section 205 determines if the power to the screen of the image display section 207 is OFF. If the screen power is OFF, the control section 205 obtains an affirmative result for step S310 and ends the processing of Figure 6. Meanwhile, if the screen power is not OFF, the control section 205 obtains a negative result for step S310 and returns to step S320 [*sic*] to repeat the processing.

[0050]

The following operational effects are obtained with the second embodiment described heretofore.

(1) Since the head motion detecting section 202 detects the motion of the passenger's head (particularly the eyes) directly, the position of the passenger's eyes can be obtained accurately irregardless of the passenger's physique and posture or whether the passenger is an adult or a child.

[0051]

(2) Since the screen vibration detecting section 203 detects the motion of the image display section 207 directly, the position of the image display section 207 can be obtained accurately in situations where the motion of the image display section 207 is different from the motion of the vehicle, such as when the image display section 207 is installed on a backrest and its position fluctuates due to the vibrations of the backrest.

[0052]

(3) The displayed image appears stationary in space to the passenger because the display position of the image (including text) displayed on the image display section 207 is moved in consideration of the relative displacement between the eyes of the passenger and the image display section 207 using the eye position mentioned in (1) above and the position of the image display section mentioned in (2) above. As a result, similarly to the

first embodiment, the image is easier for the passenger to view and the feeling on the part of the passenger that something is abnormal can be reduced.

[0053]

Although the preceding explanation described a head motion detecting section having a built-in acceleration sensor, it is also acceptable to use a built-in gyro sensor or a magnetic position sensor instead. Any of these sensors, i.e., an acceleration sensor, a gyro sensor, or a magnetic position sensor, can also be used in the vehicle motion detecting section 201 and the screen vibration detection section 203.

[0054]

It is also acceptable to photograph the passenger using a vehicle-installed camera and analyze the photographic image to obtain the motion (displacement) of the passenger's eyes.

[0055]

Regarding the vehicle-installed display device 200 in Figure 5, it is also acceptable for the image display section 207 to be held in the hand of the passenger instead of mounted to a backrest.

[0056]

(Third Embodiment)

The display device can be a portable game, a portable information terminal (PDA), a portable telephone, or the like. Figure 7 is a block diagram outlining a portable display device in accordance with a third embodiment of the present invention. In Figure 7, the portable display device 300 has a screen undulation detecting section 301, an image input section 302, a control section 303, an image displacement section 304, and an image display section 305. The viewer holes the portable display device 300 and views an

image displayed on the image display section 305.

[0057]

The screen undulation detecting section 301 detects movement of the image display section 305 at frequencies of several hertz resulting from shaking of the viewer's arm while the viewer holds the portable display device 300. The control section 303 uses the information detected by the screen undulation detecting section 301 to calculate the amount of displacement of the image display section 305. It then sends information indicating the calculated displacement amount to the image displacement section 304 and issues a command signal instructing the same to shift the image. The image displacement section 304 shifts the image in such a manner as to cancel the displacement indicated by said information.

[0058]

The following operational effects are obtained with the third embodiment described heretofore.

(1) Similarly to the first and second embodiments, the game image, electronic book, or text information displayed on the image display section 305 becomes easier for the viewer to view because the image displayed on the image display section 305 is shifted.

[0059]

(2) The portable display device 300 can be made more compact than the second embodiment because the vehicle motion detecting section 201 and the head motion detection section 202 are eliminated.

[0060]

The portable display device 300 can also be provided with a head motion detecting section like that of the second embodiment. In such a case, since the motion of the

viewer's head (particularly the eyes) can be detected with the head motion detecting section, the display position of the image (including text) displayed on the image display section 305 can be moved in consideration of the relative displacement between the viewer's head and the image display section 305 by using the detected positions of the viewer's head and the image display section. As a result, the viewability of the displayed content can improved even further.

[0061]

(Fourth Embodiment)

Figure 8 is a block diagram outlining a vehicle-installed display device in accordance with a fourth embodiment of the present invention. In Figure 8, the vehicle-installed display device 400 has a vehicle motion detecting section 401, a pedal operation detecting section 402, a control section 403, an image input section 404, an image displacement section 405, and an image display section 406. The viewer views an image displayed on the image display section 406 inside a vehicle.

[0062]

The vehicle motion detecting section 401 detects both the translational motion of the vehicle and the rotational motion of the vehicle and sends a detection signal to the control section 403. The pedal operation detecting section 402 detects operation of the accelerator pedal (not shown in drawings) and brake pedal (not shown in drawings) by the driver and sends a detection signal to the control section 403.

[0063]

The image input section 404 receives display data from an external device and sends the display data to the image displacement section 405. The control section 403 determines the amount of displacement of the image using the detection signal indicating the vehicle

motion and the detection signal indicating the pedal operations. In addition to determining the image displacement amount, the control section 403 is configured to control the other sections of the vehicle-installed display device 400. The control section 403 sends information indicating the image displacement amount determined by the control section 403 to the image displacement section 405. Based on the information indicating the amount of image displacement, the image displacement section 405 modifies the display data in such a manner that the display position of the image moves (shifts) within the display screen of the image display section 406. The image shifting is the same as in the first embodiment.

[0064]

After being modified by the image displacement section 405, the display data is sent to the image display section 406 as a display signal. The image display section 406 is, for example, a liquid crystal display device and displays images in accordance with the inputted display signal.

[0065]

The fourth embodiment is characterized in that it shifts the display image not only in accordance with the motion of the vehicle but also in accordance with the pedal operations of the vehicle.

[0066]

The flow of the display processing executed by the control section 403 of the vehicle display device 400 will now be described with reference to the flowchart of Figure 9. In step S410, the control section 403 determines if the power to the screen of the image display section 406 is ON. If the screen power is ON, the control section 403 obtains an affirmative result for step S410 and proceeds to step S420. If the screen power is not ON,

the control section obtains a negative result for step S410 and repeats step S410.

[0067]

In step S420, the control section 403 resets the image displacement (shift) amount X_{T-1} to the initial value of 0 and then proceeds to step S430. The image displacement amount X_{T-1} is the displacement amount of the image displayed on the image display section 406 immediately before the image is shifted and indicates the image display position before the image is shifted. The initial value of 0 is the image shift amount corresponding to displaying the image in the center of the display area of the image displaying section 406. When the image shift amount is 0, the center of the displayed image and the center of the display area are aligned with each other. In step S430, the control section 403 issues a command to the vehicle motion detection section 401 instructing the same to detect the motion of the vehicle (motion measurement) and then proceeds to step S440. In response to the command, the vehicle motion detection section 401 detects both the translational motion and the rotational motion of the vehicle. In step S440, the control section 403 issues a command to the pedal operation detecting section 402 instructing the same to detect operation of the pedals (pedal operation measurement) and then proceeds to step S450.

[0068]

In step S450, the control section 403 uses the detection signal indicating the vehicle motion to calculate the screen movement amount ΔX_H for which the movement frequency f at which the screen moves translationally due to the rotational motion of the vehicle exceeds a prescribed frequency fc. Then the control section proceeds to step S460. The screen movement amount includes movement in both the pitch (up and down) and the roll (left and right) directions of the image display section 406. The screen movement

that occurs during constant-speed travel is generally divided into movements in a very low frequency range (f < fc) where the passenger does not experience a feeling that something is abnormal about the visual information even when watching the display screen intently and movements in a frequency range (f ≥fc) where there is the possibility that the passenger will experience a feeling that something is abnormal about the visual information. In step S450, the screen movement amount ΔX_H is obtained for the frequency region (f ≥fc) where there is the possibility that the passenger will experience a feeling that something is abnormal about the visual information when traveling at a constant speed.

[0069]

In step S460, the control section 403 uses the detection signal indicating the vehicle motion to calculate the screen movement amount ΔX_L for the very low frequency region (f < fc) and then proceeds to step S470. The screen movement amount includes movement in both the pitch (up and down) and the roll (left and right) directions of the image display section 406.

[0070]

In step S470, the control section 403 determines if an acceleration or deceleration operation is being executed. If it receives a detection signal from the pedal operation detecting section 402, the control section 403 obtains an affirmative result for step S470 and proceeds to step S480. If it receives a detection signal from the pedal operation detecting section 402, the control section 403 obtains a negative result for step S470 and proceeds to step S490.

[0071]

Step S480 is executed in cases where an acceleration or deceleration operation is being

executed. When acceleration or deceleration occurs, the vehicle undergoes motion in the pitch direction or roll direction in response to inertial forces and the screen moves. This vehicle motion includes very low frequency movements, e.g., movements at frequencies from 0.2 to 0.3 Hz. Thus, when it is determined that an acceleration or deceleration operation is taking place, the image shift amount is calculated based on the screen movement amount ΔX_L for the very low frequency region ($f < fc$), which includes the aforementioned frequencies, and the screen movement amount ΔX_H for the frequency region $f \geq fc$.

[0072]

In step S480, the control section 403 uses the equation below to calculate the translational image shift amount X_T resulting from the rotational motion of the vehicle and the acceleration or deceleration operation and then proceeds to step S510.

[Equation 1]

$$X_T = X_{T-1} - \Delta X_H - \Delta X_L \qquad (1)$$

X_{T-1} is the image shift amount immediately before the image is shifted. The reason the screen movement amount ΔX_H and the screen movement amount ΔX_L are subtracted from the image shift amount X_{T-1} is to shift the image in the opposite direction as the direction of the screen movement.

[0073]

In step S510, the control section 403 sends information indicating the calculated image shift amount X_T to the image displacement section 405 and issues a command instructing the same to shift the image. In response to the command, the image displacement section

405 modifies the display data received from the image input section 404 in accordance with the shift amount X_T. Meanwhile, the control section proceeds to step S520.

[0074]

In step S520, the control section 403 issues a command to the image display section 406 instructing the same to display the image described by the modified display data and then proceeds to step S530. In response to the command, the image display section 406 displays an image that has been moved within the screen. In step S530, the control section 403 substitutes the current shift amount X_T as the value for X_{T-1} (i.e., replaces X_{T-1} with the current shift amount X_T) and then proceeds to step S540. In step S540, the control section 403 determines if the power to the screen of the image display section 406 is OFF. If the screen power is OFF, the control section 403 obtains an affirmative result for step S540 and ends the processing of Figure 9. Meanwhile, if the screen power is not OFF, the control section 403 obtains a negative result for step S540 and returns to step S430 [*sic*] to repeat the processing.

[0075]

Step S490 is executed in cases where an acceleration or deceleration operation is not being executed. In such cases, the screen movement amount ΔX_L corresponding to the very low frequency region ($f < fc$) is ignored. In step S490, the control section 403 calculates the average screen movement amount X_M corresponding to a prescribed period of time T immediately preceding the point in time when the calculation is made and then proceeds to step S500.

[0076]

In step S500 the control section 403 calculates the translational image shift amount X_T resulting from rotational motion of the vehicle using Equation (2) below and then

proceeds to step S510.

[Equation 2]

$X_T = X_{T-1} - \Delta X_H - X_M \times A$

X_{T-1} is the image shift amount immediately before the image is shifted and A is a prescribed coefficient. The reason the screen movement amount ΔX_H and the product of the average screen movement amount ΔX_M [*sic*] and the coefficient A are subtracted from the image shift amount X_{T-1} is to shift the image in the opposite direction as the direction of the screen movement.

[0077]

The average screen movement amount X_M indicates the average display position of the image displayed in the display area of the image display section 406. In Equation (2), the image shift amount X_T is brought closer to the initial value of 0 calculated in step S420 by subtracting the average screen movement amount X_M from the image shift amount X_{T-1}. In other words, the image shift amount is calculated in such a manner as to bring a prescribed position (e.g., the center) of the displayed image closer to a prescribed position (e.g., the center) of the display area of the image display section 406.

[0078]

The processing of step S490 should be executed no faster than once every three seconds because when neither an acceleration operation nor a deceleration operation is being executed, it is not necessary to use information related to the very low frequency region ($f < fc$), which includes frequencies of 0.2 to 0.3 Hz. Also, it is preferred that the prescribed coefficient A be a small value in order to move the display position of the image toward the center of the screen gradually when the average screen movement amount is X_M is large.

[0079]

Figure 10 shows the parameters used for calculating the image shift amount. In Figure 10, a circle (○) indicates that the parameter is used in the calculation and an X (×) indicates that the parameter is not used in the calculation. When traveling at a constant speed, the calculation is accomplished using the display position (i.e., image shift amount) X_{T-1} immediately before shifting the image, the screen displacement change amount (i.e., screen movement amount) ΔX_H for the frequency region $f \geq fc$, and the average displacement (i.e., screen movement amount) XM during the time period T. When acceleration or deceleration is occurring, the calculation is accomplished using the display position (i.e., image shift amount) X_{T-1} immediately before shifting the image, the screen position change amount (i.e., screen movement amount) ΔX_H for the frequency region $f \geq fc$, and the screen position change amount (i.e., screen movement amount) ΔX_L for the frequency region $f < fc$.

[0080]

The following operational effects are obtained with the fourth embodiment described heretofore.

(1) When calculating the movement amount of the image display section 406 in the pitch direction (up and down) resulting from rotational motion of the vehicle, the following two image shift amounts are calculated: [1] a screen movement amount ΔX_L corresponding to a very low frequency range ($f < fc$) where there is the possibility that the visual information will cause the passenger to experience a feeling of discomfort or a feeling that something is abnormal when the vehicle is accelerating or decelerating; and [2] a screen movement amount ΔX_H corresponding to a frequency region $f \geq fc$ where there is the possibility that the visual information will cause the passenger to experience a feeling

of discomfort or a feeling that something is abnormal both when the vehicle is accelerating or decelerating and when the vehicle is traveling at a constant speed. When a pedal operation was detected (affirmative result for step S470), the display position of the image displayed on the image display section 406 is moved (shifted) in the pitch direction in such a manner as to cancel the movement of the display image resulting from both of the aforementioned movement amounts, i.e., the screen movement amount ΔX_L and the screen movement amount ΔX_H. As a result, the display image appears stationary in space to the passenger. Thus, the image is easier for the passenger to view when a longitudinal G-force (acceleration) occurs and since the visual information the passenger obtains when watching the display screen matches the information from the vestibular organs (semicircular canals and otolith organs), the feeling that something is abnormal and feelings of discomfort can be reduced in comparison with a case in which the image is not shifted.

[0081]

(2) When a pedal operation is not detected (negative result for step S470), the screen movement amount ΔX_H and the product of the average screen movement amount ΔX_M the coefficient A are used to cancel the movement of the display image resulting from the screen movement amount ΔXH and move (shift) the image such that the average display position moves closer to the center of the screen of the image display section 406. As a result, when there is no forward or rearward G-force (acceleration), movement of the display screen resulting from the screen movement amount ΔX_H in the vicinity of the resonance frequency of the vehicle (e.g., 1 to 2 Hz) can be canceled without compensating for screen movement amount resulting from stead-state leaning of the vehicle due to a slanted road surface or the like. Also, by moving the average display

position toward the center of the screen, the image can be displayed in a position that is easy to view when the vehicle enters an upward or downward slope from a flat road and more leeway can be secured for compensating for upward and downward movement of the image display section 406 resulting from acceleration or deceleration when traveling on a slope.

[0082]

Although the fourth embodiment was described using rotational motion of the vehicle in the pitch direction during acceleration or deceleration as an example, the similar processing can be executed with respect to rotational motion of the vehicle in the rolling direction (left and right) during cornering. It can be determined if a cornering operation is being performed by detecting at least one of the following: steering operation, lateral acceleration, and yaw acceleration.

[0083]

(Fifth Embodiment)

Figure 11 is a block diagram outlining a vehicle-installed display device in accordance with a fifth embodiment of the present invention. In Figure 11, the vehicle-installed display device 500 has a vehicle motion detecting section 501, a control section 503, an image input section 504, an image displacement section 505, and an image display section 506. The viewer views an image displayed on the image display section 506 inside a vehicle.

[0084]

The vehicle motion detecting section 501 detects the translational motion and the rotational motion of the vehicle and sends a detection signal to the control section 503. The vehicle motion detection section 501 also measures the change in vehicle speed ΔV.

The change in vehicle speed ΔV is the difference between the vehicle speed detected in the previous control cycle and the newly detected vehicle speed. The image input section 504 receives image data from an external device and sends the image data to the image displacement section 505. The control section 503 determines the amount of displacement of the image using the detection signal indicating the vehicle motion. In addition to determining the amount of image displacement, the control section 503 is configured to control the other sections of the vehicle-installed display device 500. The control section 503 sends information indicating the amount of image displacement determined by the control section 503 to the image displacement section 505. Based on the information indicating the amount of image displacement, the image displacement section 505 modifies the display data in such a manner that the position of the image (including text) moves (shifts) within the display screen of the image display section 506. The image shifting is the same as in the first embodiment.

[0085]

After being modified by the image displacement section 505, the display data is sent to the image display section 506 as a display signal. The image display section 506 is, for example, a liquid crystal display device and displays images in accordance with the inputted display signal.

[0086]

The fifth embodiment is characterized in that it shifts the displayed image not only in accordance with the motion of the vehicle but also in accordance with whether or not deceleration or acceleration is determined to be taking place.

[0087]

The flow of the display processing executed by the control section 503 of the vehicle

display device 500 will now be described with reference to the flowchart of Figure 12. In step S610, the control section 503 determines if the power to the screen of the image display section 506 is ON. If the screen power is ON, the control section 503 obtains an affirmative result for step S610 and proceeds to step S620. If the screen power is not ON, the control section obtains a negative result for step S610 and repeats step S610.

[0088]

In step S620, the control section 503 resets the image displacement (shift) amount X_{T-1} to the initial value of 0 and then proceeds to step S630. The image displacement amount X_{T-1} is the displacement amount of the image displayed on the image display section 506 immediately before the image is shifted and indicates the image display position before the image is shifted. In step S630, the control section 503 issues a command to the vehicle motion detection section 501 instructing the same to detect the motion of the vehicle (motion measurement) and then proceeds to step S650. In response to the command, the vehicle motion detection section 501 detects the translational motion, the rotational motion, and the change in speed ΔV of the vehicle.

[0089]

In step S650, the control section 503 uses the detection signal indicating the vehicle motion to calculate the screen movement amount ΔX_H for which the movement frequency f at which the screen moves translationally due to the rotational motion of the vehicle exceeds a prescribed frequency fc. Then the control section proceeds to step S660. The screen movement amount includes movement in both the pitch (up and down) and the roll (left and right) directions of the image display section 506. The prescribed frequency f is the same as the frequency described in the fourth embodiment.

[0090]

In step S660, the control section 503 uses the detection signal indicating the vehicle motion to calculate the screen movement amount ΔX_L for the very low frequency region ($f < fc$) and then proceeds to step S670. The screen movement amount includes movement in both the pitch (up and down) and the roll (left and right) directions of the image display section 406 [*sic*].

[0091]

In step S670, the control section 403 determines if an acceleration or deceleration operation is being executed. If the absolute value of the change in vehicle speed $|\Delta V|$ is found to satisfy the relationship $|\Delta V| \geq \Delta V0$, where $\Delta V0$ is a predetermined threshold value, the control section 503 obtains an affirmative result for step S670 and proceeds to step S680. If the relationship $|\Delta V| \geq \Delta V0$ is not satisfied, the control section obtains a negative result for step S670 and proceeds to step S690.

[0092]

Step S680 is executed in cases where an acceleration or deceleration operation is considered to be in progress. In step S680, the control section 503 uses the aforementioned Equation 1 to calculate the translational image shift amount X_T resulting from the rotational motion of the vehicle and the acceleration or deceleration operation and then proceeds to step S710.

[0093]

In step S710, the control section 503 sends information indicating the calculated image shift amount X_T to the image displacement section 505 and issues a command instructing the same to shift the image. In response to the command, the image displacement section 505 modifies the display data received from the image input section 504 in accordance with the shift amount X_T. Meanwhile, the control section proceeds to step S720.

[0094]

In step S720, the control section 503 issues a command to the image display section 506 instructing the same to display the image described by the modified display data and then proceeds to step S730. In response to the command, the image display section 506 displays an image that has been moved within the screen. In step S730, the control section 503 substitutes the current shift amount X_T as the value for X_{T-1} (i.e., replaces X_{T-1} with the current shift amount X_T) and then proceeds to step S740. In step S740, the control section 503 determines if the power to the screen of the image display section 606 is OFF. If the screen power is OFF, the control section 503 obtains an affirmative result for step S740 and ends the processing of Figure 12. Meanwhile, if the screen power is not OFF, the control section 503 obtains a negative result for step S740 and returns to step S630 [*sic*] to repeat the processing.

[0095]

Step S690 is executed in cases where an acceleration or deceleration operation is not considered to be in progress. In such cases, the screen movement amount ΔX_L corresponding to the very low frequency region ($f < fc$) is ignored. In step S690, the control section 503 calculates the average screen movement amount X_M corresponding to a prescribed period of time T immediately preceding the point in time when the calculation is made. Then, the control section proceeds to step S700.

[0096]

In step S700 the control section 503 calculates the translational image shift amount X_T resulting from rotational motion of the vehicle using the aforementioned Equation (2) and then proceeds to step S710.

[0097]

The following operational effects are obtained with the fifth embodiment described heretofore.

(1) When it is determined that an acceleration or deceleration operation of the vehicle is in progress (affirmative result for step S670), the display position of the image displayed on the image display section 506 is moved (shifted) in the pitch direction in order to cancel the movement of the displayed image resulting from both the screen movement amount ΔX_L and the screen movement amount ΔX_H. As a result, similarly to the fourth embodiment, the image is easier for the passenger to view when a longitudinal G-force (acceleration) occurs and a feeling that something is abnormal and feelings of discomfort experienced when watching the display screen intently can be reduced.

[0098]

(2) When it is determined that an acceleration or deceleration operation of the vehicle is not in progress (negative result for step S670), the screen movement amount ΔX_H and the product of the average screen movement amount ΔX_M the coefficient A are used to cancel the movement of the displayed image resulting from the screen movement amount ΔX_H and move (shift) the image such that the average display position moves closer to the center of the screen of the image display section 506. As a result, similarly to the fourth embodiment, when there is no forward or rearward G-force (acceleration), movement of the display screen resulting from the screen movement amount ΔX_H in the vicinity of the resonance frequency of the vehicle (e.g., 1 to 2 Hz) can be canceled without compensating for the movement of the displayed image resulting a slanted road surface or the like. Also, by moving the average display position toward the center of the screen, the image can be displayed in a position that is easy to view when the vehicle enters an upward or downward slope from a flat road and more leeway can be secured for

compensating for upward and downward movement of the image display section 406 resulting from acceleration or deceleration when traveling on a slope.

[0099]

(3) Since the size of the change in the vehicle speed ΔV is used to determine if an acceleration or deceleration operation is being executed, the pedal operation detecting section of the fourth embodiment can be eliminated.

[0100]

The correspondence between the constituent elements of the claims and the constituent elements of the embodiments will now be explained. The vehicle motion detecting means is constituted by, for example, the vehicle motion detection section 101 (201, 401, 501). The display means is constituted by, for example, the image display section 108 (207, 305, 406, 506). The translational displacement corresponds, for example, to the image movement amount. The displayed image displacement computing means and relative displacement computing means are constituted by, for example, the control section 106 (205, 303, 403, 503). The display control means is constituted by, for example, the image displacement section 107 (206, 304, 405, 505). The motion value determining means is constituted by, for example, the head motion detecting section 202 or a passenger motion estimating section 104. The response function corresponds to, for example, the transmission function. The motion detecting means is constituted by, for example, an image vibration detecting section 203 (image undulation detecting section 301). The center deviation computing means and acceleration/deceleration operation determining means are constituted by, for example, the control section 403 (503). Moreover, so long as the characteristic functions of the invention are not lost, the constituent elements of the present invention are not limited to those described

heretofore.

[0101]

Although the preceding embodiments are described under the assumption that the vehicle was traveling on a stable road surface, it is possible that an actual road surface will be slanted forward, rearward, left, or right (slope, cant, or the like). The surface roughness also varies from road to road, causing slight variations in the vibration input. Thus, there are certainly cases in which the aforementioned screen movement amount will be adjusted in accordance with the state of the road surface.

[BRIEF DESCRIPTIONS OF THE DRAWINGS]

Figure 1 is a block diagram outlining a vehicle-installed display device in accordance with a first embodiment of the present invention.

Figure 2 is a flowchart illustrating the flow of the display processing executed by the control section.

Figure 3 (a) illustrates displacement of the screen position due to pitch motion of the vehicle; (b) illustrates the image shift executed in order to cancel the pitch motion of the vehicle when the vehicle nosedives; (c) illustrates the image shift executed in order to cancel the pitch motion of the vehicle when the vehicle squats.

Figure 4 (a) illustrates displacement of the screen position due to pitch motion of the passenger's head; (b) illustrates the image shift executed in order to cancel the pitch motion of the passenger's head (particularly the eyes) when the passenger's head pitches

forward.

Figure 5 is a block diagram outlining a vehicle-installed display device in accordance with a second embodiment of the present invention.

Figure 6 is a flowchart illustrating the flow of the display processing executed by the control section.

Figure 7 is a block diagram outlining a vehicle-installed display device in accordance with a third embodiment of the present invention.

Figure 8 is a block diagram outlining a vehicle-installed display device in accordance with a fourth embodiment of the present invention.

Figure 9 is a flowchart illustrating the flow of the display processing executed by the control section.

Figure 10 shows the parameters used in the calculations of the image shift amount.

Figure 11 is a block diagram outlining a vehicle-installed display device in accordance with a fifth embodiment of the present invention.

Figure 12 is a flowchart illustrating the flow of the display processing executed by the control section.

[DESCRIPTIONS OF THE REFERENCE SYMBOLS]

100 (200, 400, 500) vehicle-installed display device

101 (201, 401, 501) vehicle motion detecting section

102 seat surface pressure detecting section 103 human body database section

104 passenger motion estimating section

105 (204, 302, 404, 504) image input section

106 (205, 303, 403, 503) control section

107 (206, 304, 405, 505) image displacement section

108 (207, 305, 406, 506) image display section

202 head motion detecting section 203 screen vibration detecting section

300 portable display device 301 screen undulation detecting section

402 pedal operation detecting section

Figure 1

101 vehicle motion detecting section

102 seat surface pressure detecting section

103 human body database section

104 passenger motion estimating section

105 image input section

106 control section

107 image displacement section

108 image display section

Figure 2

S10 Is screen power ON?

S20 Measure body pressure.

S30 Estimate physique and posture.

S40 Measure vehicle motion.

S50 Has posture changed?

S60 Select human body vibration transmission function.

S70 Estimate head motion.

S80 Calculate screen movement amount resulting from vehicle rotation.

S90 Calculate relative displacement between screen and eyes.

S100 Calculate image displacement amount

S110 Shift image.

S120 Display image.

S130 Is screen power OFF?

Figure 3

(a)

* Screen moves downward due to nosedive of vehicle.

Screen

Relative displacement between ground surface and vehicle (screen displacement due to pitch motion of vehicle)

* The image is shifted upward when the vehicle nosedives and downward when the vehicle squats.

Screen

(b) Nosedive (c) Squat

Figure 4

Height of eyes changes Screen Screen

* The image is shifted downward when the passenger's head rotates forward and upward when the passenger's head rotates rearward.

Relative displacement between vehicle and passenger (change in eye height due to pitch motion of head)

Figure 5

201 vehicle motion detecting section

202 head motion detecting section

203 screen vibration detecting section

204 image input section

205 control section

206 image displacement section

207 image display section

Figure 6

S210 Is screen power ON?

S220 Measure vehicle motion.

S230 Measure screen vibration.

S240 Measure head motion.

S250 Calculate screen movement amount resulting from vehicle rotation.

S260 Calculate relative displacement between vehicle and eyes.

S270 Calculate relative displacement between vehicle and screen.

S280 Calculate image displacement amount

S290 Shift image.

S300 Display image.

S310 Is screen power OFF?

Figure 7

301 screen undulation detecting section

302 image input section

303 control section

304 image displacement section

305 image display section

Figure 8

401 vehicle motion detecting section

402 pedal operation detecting section

403 control section

404 image input section

405 image displacement section

406 image display section

Figure 9

S410 Is screen power ON?

S430 Measure vehicle motion.

S440 Measure pedal operation

S450 Calculate screen movement ΔX_H ($f \geq fc$) resulting from vehicle rotation.

S460 Calculate screen movement ΔX_L ($f < fc$) resulting from vehicle rotation.

S470 Is and acceleration or deceleration operation in progress?

S480 Calculate image shift amount:

S490 Calculate average displacement X_M for time period T.

S500 Calculate image shift amount:

S510 Shift image.

S520 Display image.

S540 Is screen power OFF?

Figure 10

Display position XT-1 immediately before calculation

Change in screen position ΔX_H at $f \geq fc$

Change in screen position ΔX_L at $f < fc$

Average displacement X_M during time period T

Steady-state travel

Acceleration or deceleration

Figure 11

501 vehicle motion detecting section

503 control section

504 image input section

505 image displacement section

506 image display section

Figure 12

S610 Is screen power ON?

S630 Measure vehicle motion.

S650 Calculate screen movement ΔX_H ($f \geq fc$) resulting from vehicle rotation.

S660 Calculate screen movement ΔX_L ($f < fc$) resulting from vehicle rotation.

S680 Calculate image shift amount:

S690 Calculate average displacement X_M for time period T.

S700 Calculate image shift amount:

S710 Shift image.

S720 Display image.

S740 Is screen power OFF?

[Document Type] Abstract

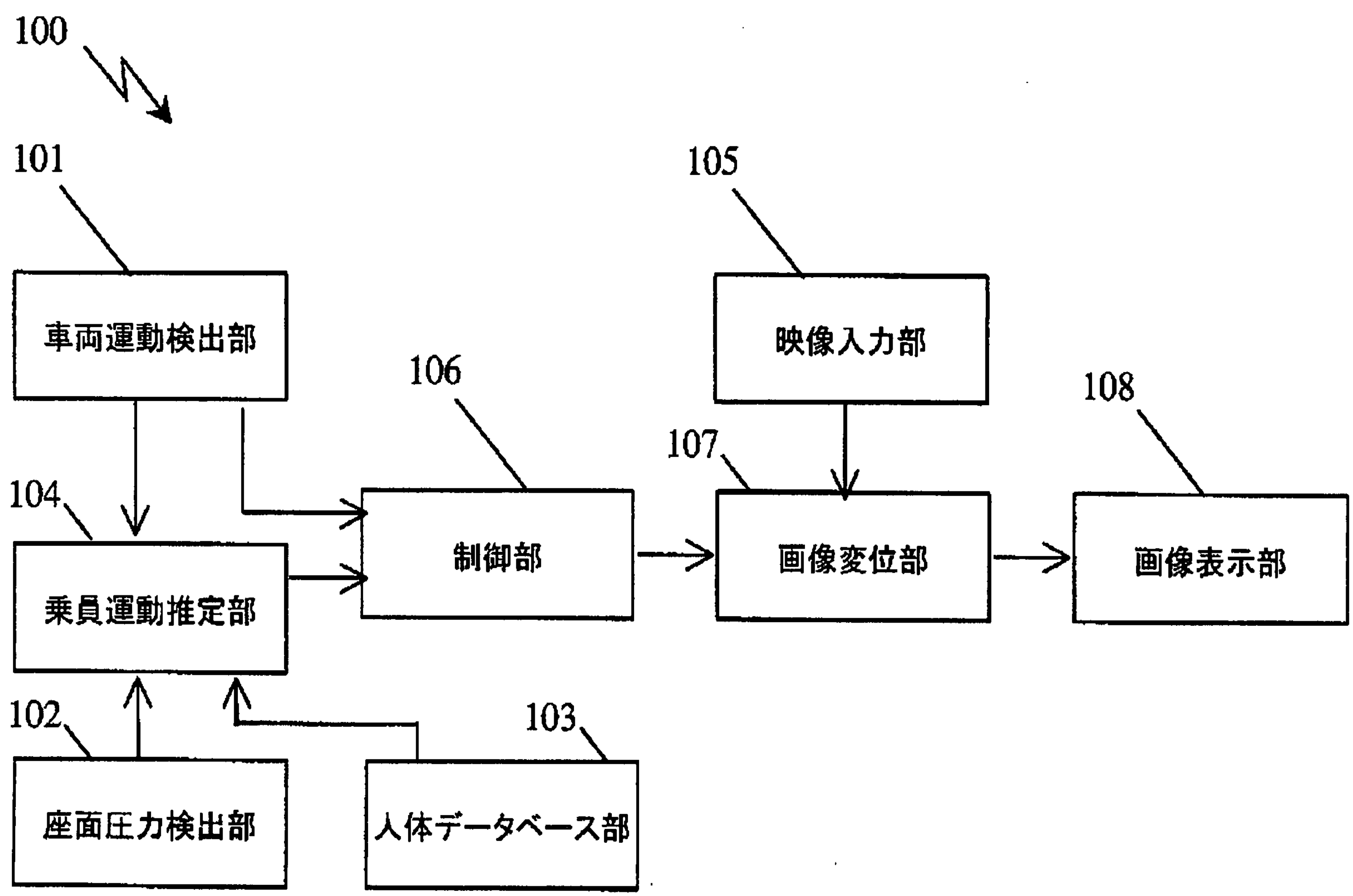
[Abstract]

[OBJECT] To provide a vehicle-installed display device that does not cause the viewer to experience a feeling that something is abnormal, even when the relative positions of the display device and the viewer fluctuate.

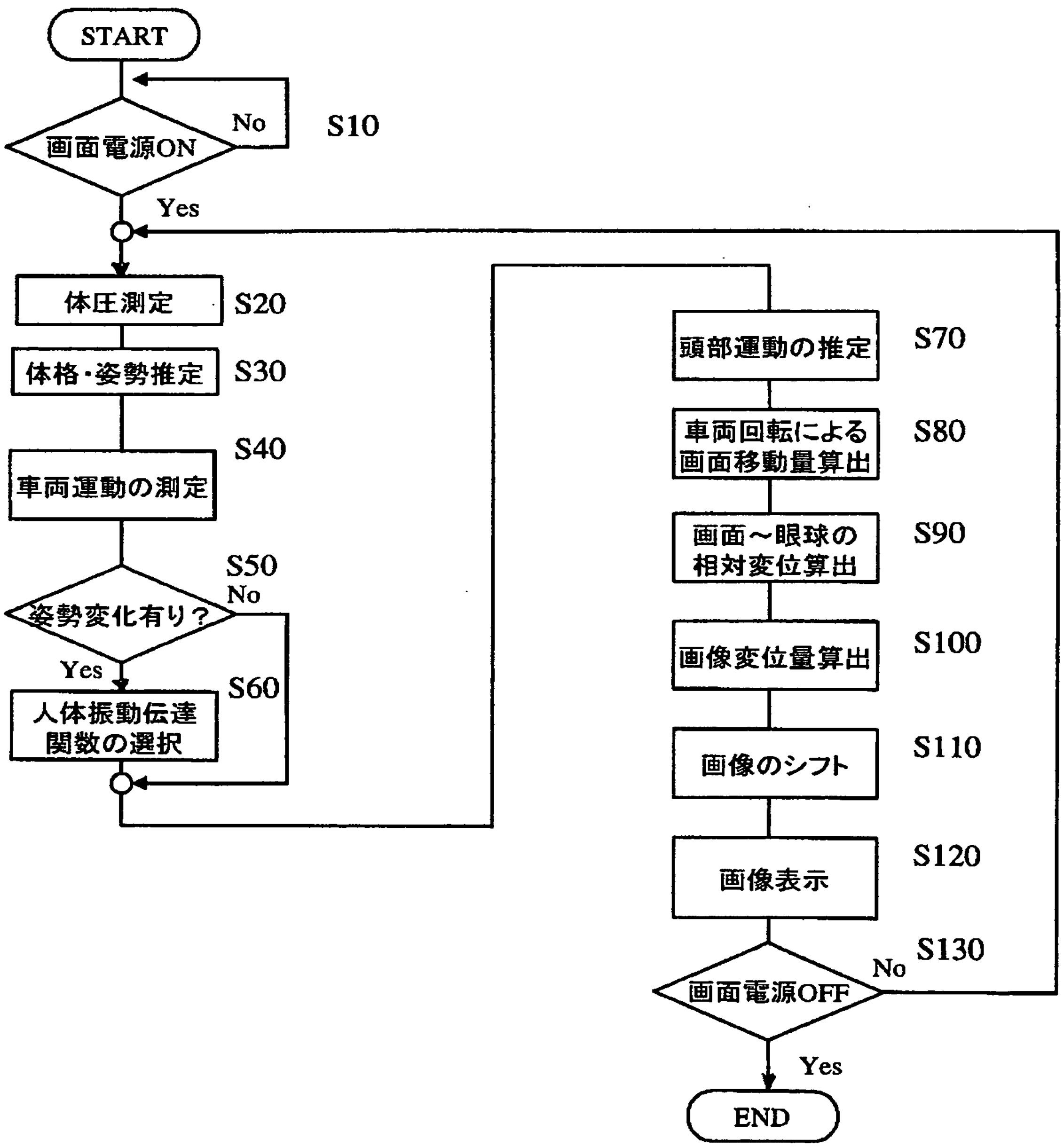
[CONSTITUTION] The vehicle-installed display device 100 measures the state of the pressure exerted on a seat by a passenger, estimates the passenger's physique and sitting posture by searching a database 103, and selects human body vibration transmission function. Using the human body vibration transmission function and detection data indicating the motion of the vehicle, the display device calculates an estimate value for the motion of the passenger's head (particularly the eyes). Using the detection data that indicates the motion of the vehicle, the display device calculates the amount of movement of the image display section 108 in the pitch direction. Using the estimated position of the passenger's eyes and the position of the image display section 108, the display device calculates the relative displacement between the passenger's eyes and the image display section. The display device moves the display position of the image displayed on the image display section 108 in such a manner as to cancel the movement of the displayed image that results from the movement of the image display section 108 in the pitch direction and the said relative displacement. As a result, the displayed image appears stationary in space to the passenger.

[Selected Drawing] Figure 1

【図1】


100
101
車両運動検出部
104
乗員運動推定部
102
座面圧力検出部
103
人体データベース部
106
制御部
105
映像入力部
107
画像変位部
108
画像表示部

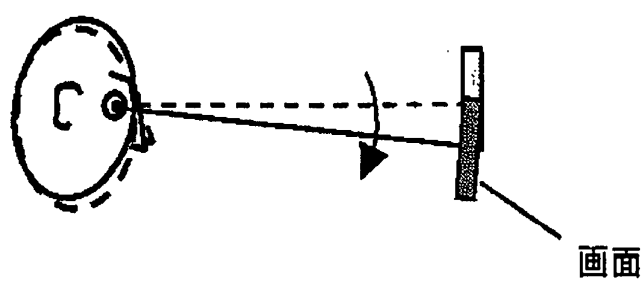
【図2】



START
画面電源ON
No
S10
Yes
体圧測定
S20
体格・姿勢推定
S30
S40
車両運動の測定
S50
No
姿勢変化有り？
Yes
S60
人体振動伝達関数の選択
頭部運動の推定
S70
車両回転による画面移動量算出
S80
画面～眼球の相対変位算出
S90
画像変位量算出
S100
画像のシフト
S110
画像表示
S120
S130
No
画面電源OFF
Yes
END

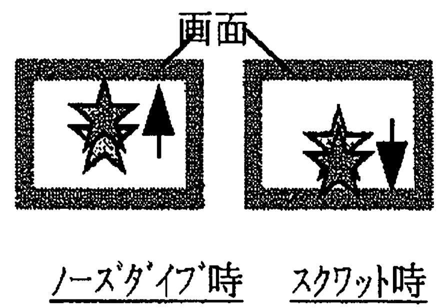
【図3】

※車両のノーズダイブにより画面が下方に移動



(a)

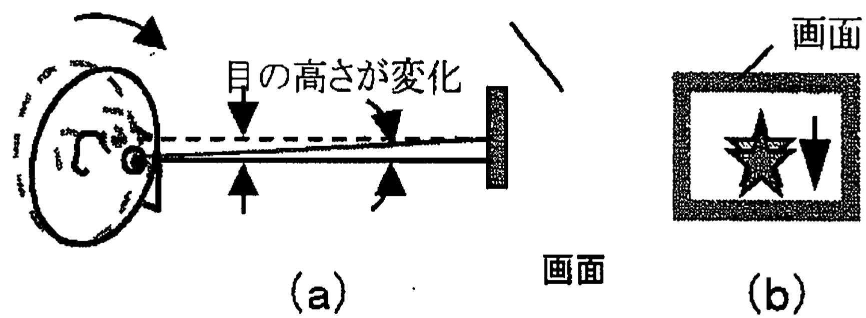
※車両のノーズダイブ時は画像を上方に、スクワット時は下方にシフトさせる。



(b)　(c)

地面～車両の相対変位(車両ピッチ動による画面変位)

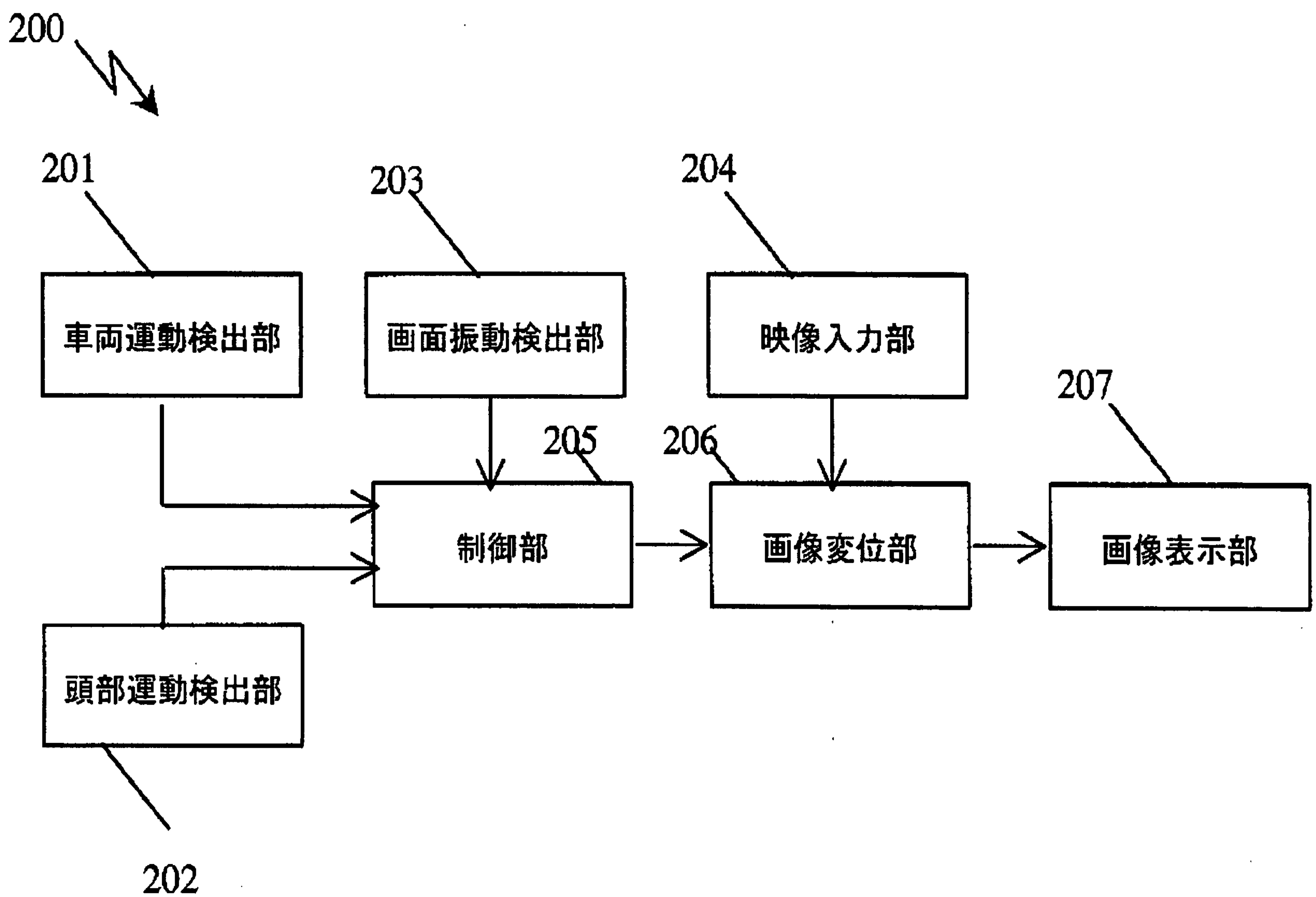
【図4】



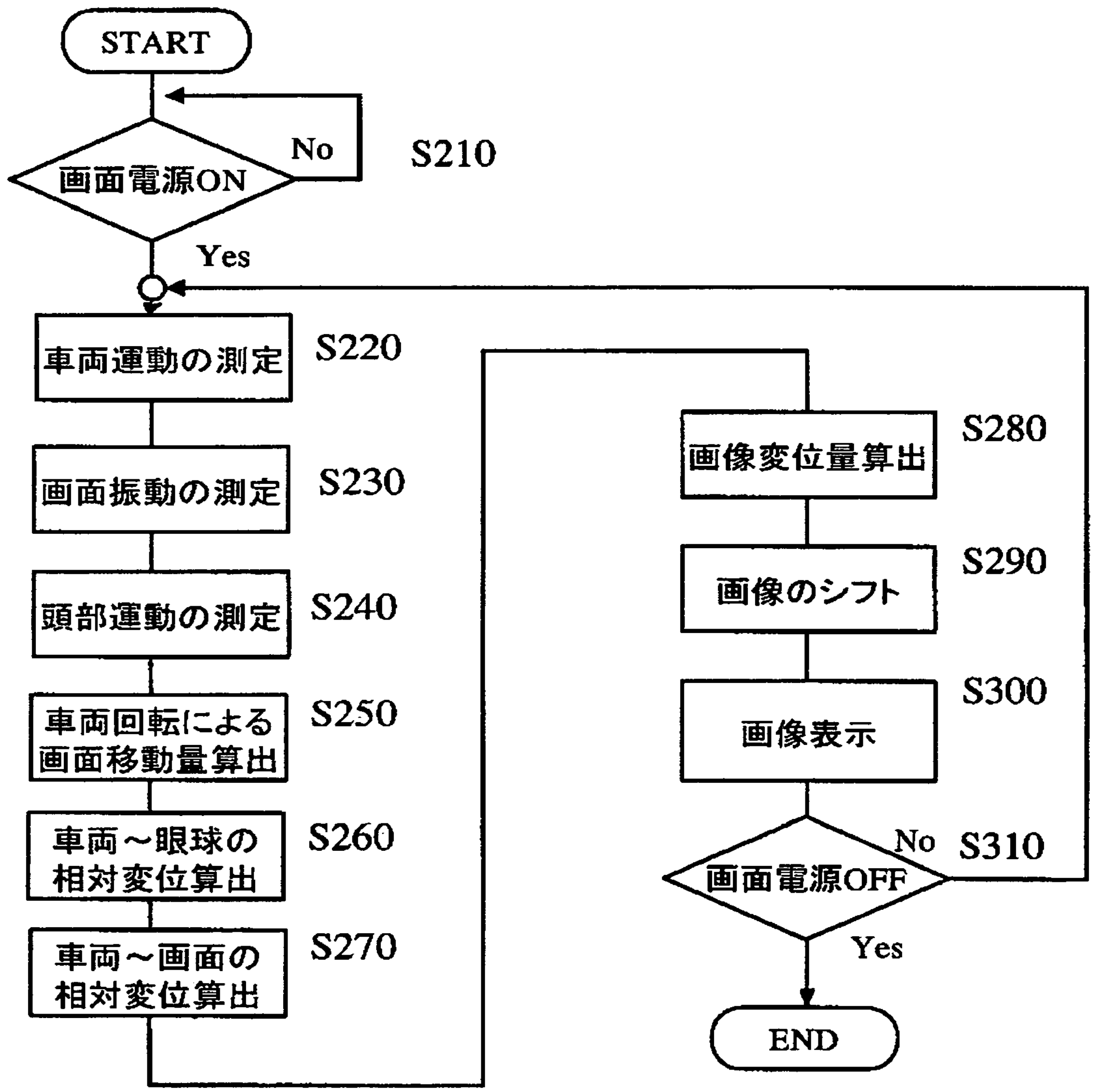
※頭部前方回転時は画像を下方に、後方回転時は画像を上方にシフトさせる。

車両～乗員の相対変位(頭部ピッチ動による目の高さの変化)

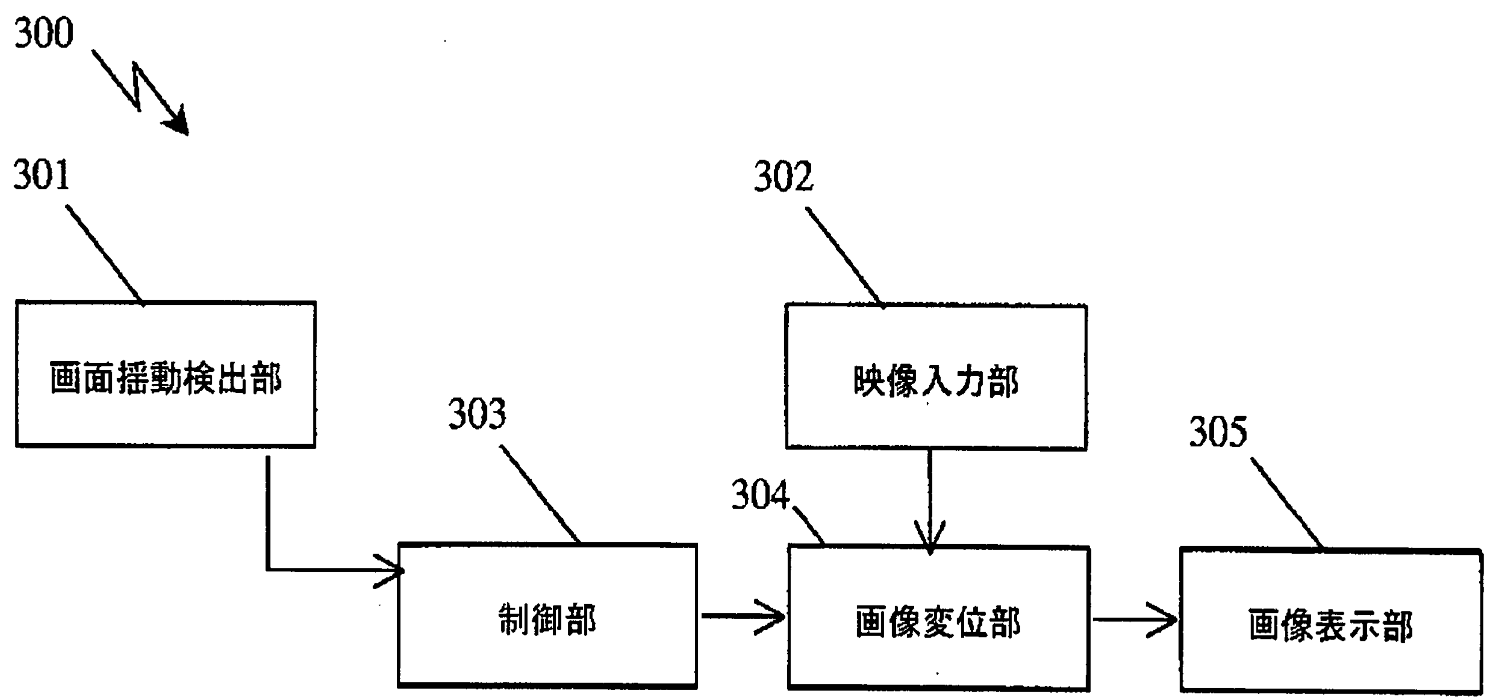
【図5】


200
201
車両運動検出部
203
画面振動検出部
204
映像入力部
205
制御部
206
画像変位部
207
画像表示部
頭部運動検出部
202

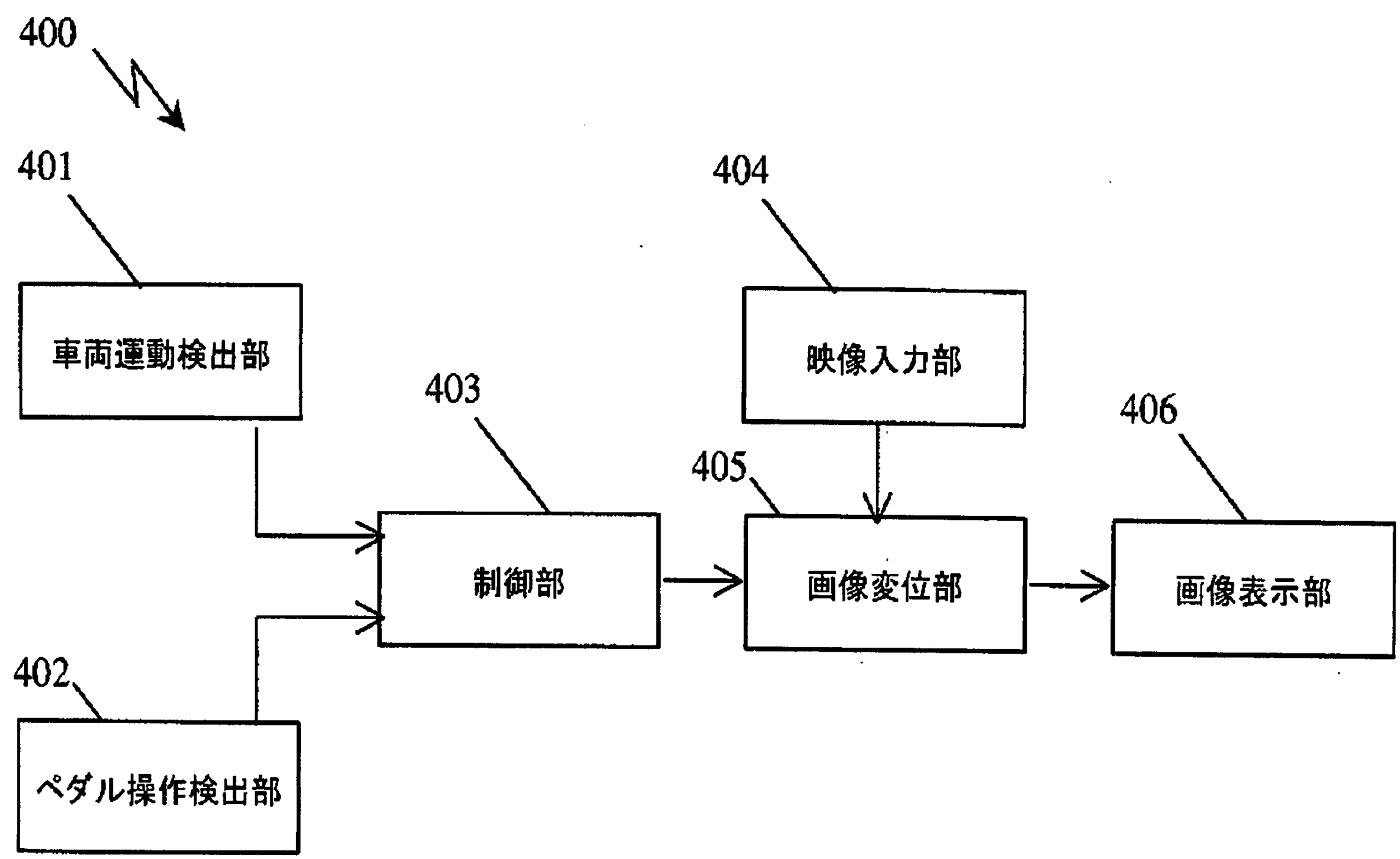
【図6】


START
画面電源ON
No
S210
Yes
車両運動の測定
S220
画面振動の測定
S230
頭部運動の測定
S240
車両回転による
画面移動量算出
S250
車両～眼球の
相対変位算出
S260
車両～画面の
相対変位算出
S270
画像変位量算出
S280
画像のシフト
S290
画像表示
S300
画面電源OFF
No
S310
Yes
END

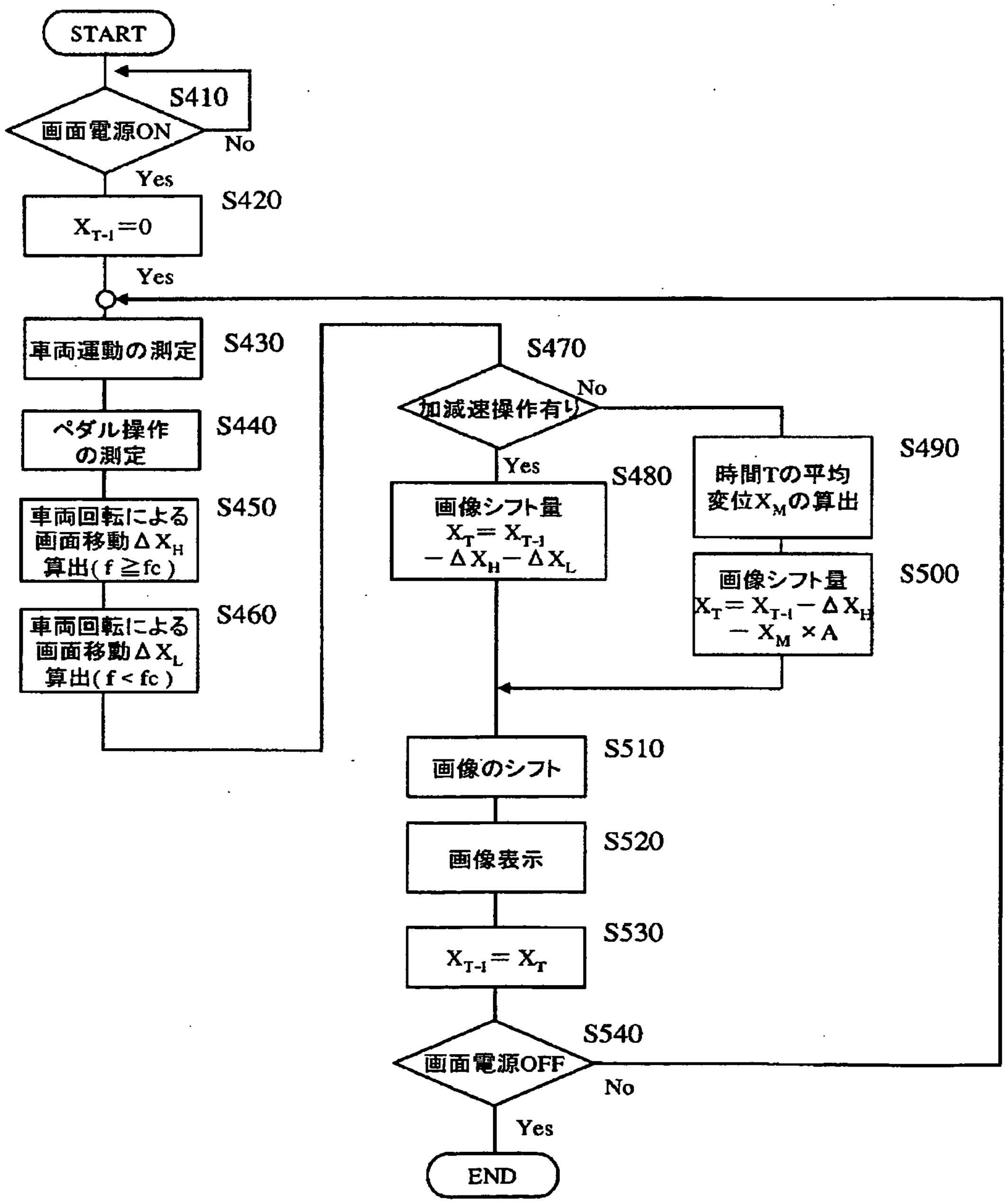
【図7】



【図8】


400
401
車両運動検出部
402
ペダル操作検出部
403
制御部
404
映像入力部
405
画像変位部
406
画像表示部

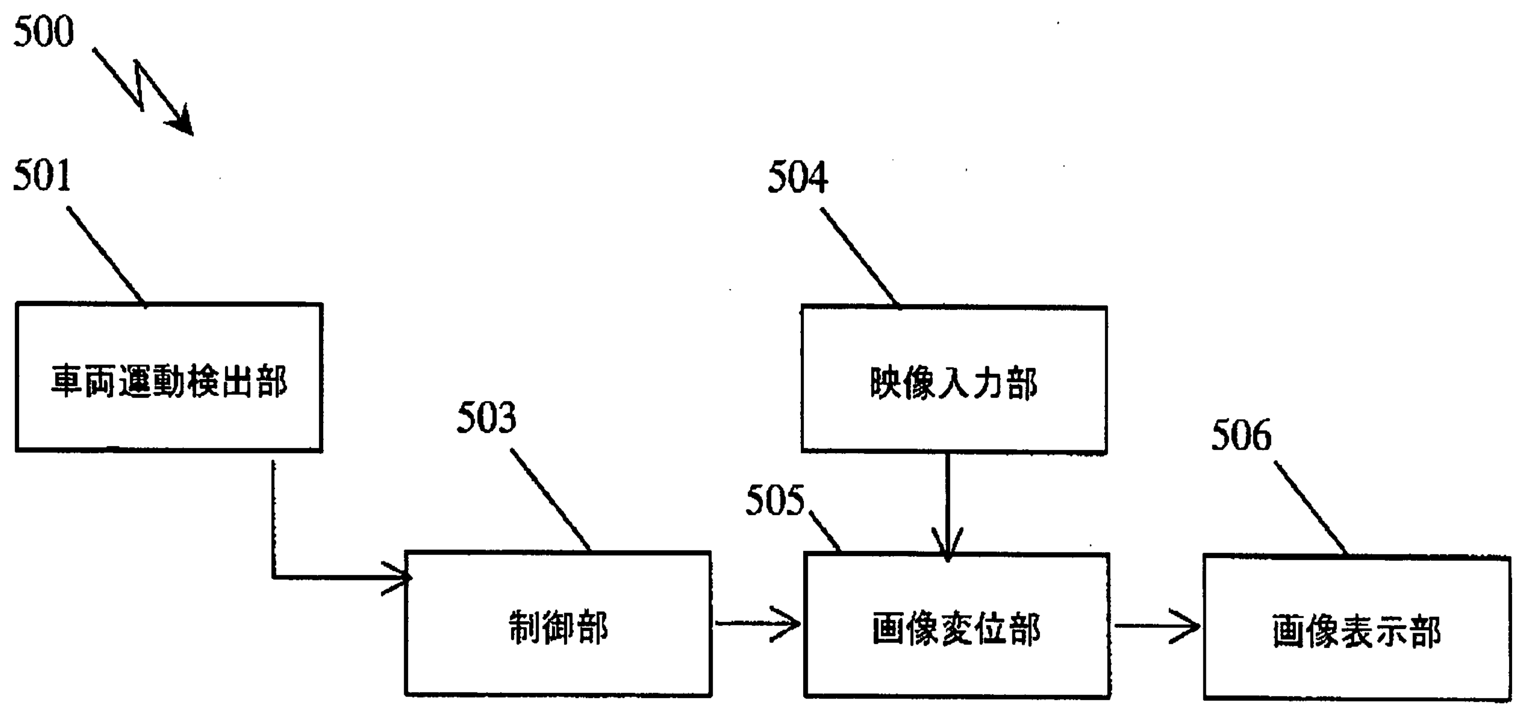
【図9】


START
S410
画面電源ON
No
Yes
S420
$X_{T-1}=0$
Yes
S430
車両運動の測定
S440
ペダル操作の測定
S450
車両回転による画面移動ΔX_H算出($f \geqq fc$)
S460
車両回転による画面移動ΔX_L算出($f < fc$)
S470
加減速操作有り
No
Yes
S480
画像シフト量 $X_T = X_{T-1} - \Delta X_H - \Delta X_L$
S490
時間Tの平均変位X_Mの算出
S500
画像シフト量 $X_T = X_{T-1} - \Delta X_H - X_M \times A$
S510
画像のシフト
S520
画像表示
S530
$X_{T-1} = X_T$
S540
画面電源OFF
No
Yes
END

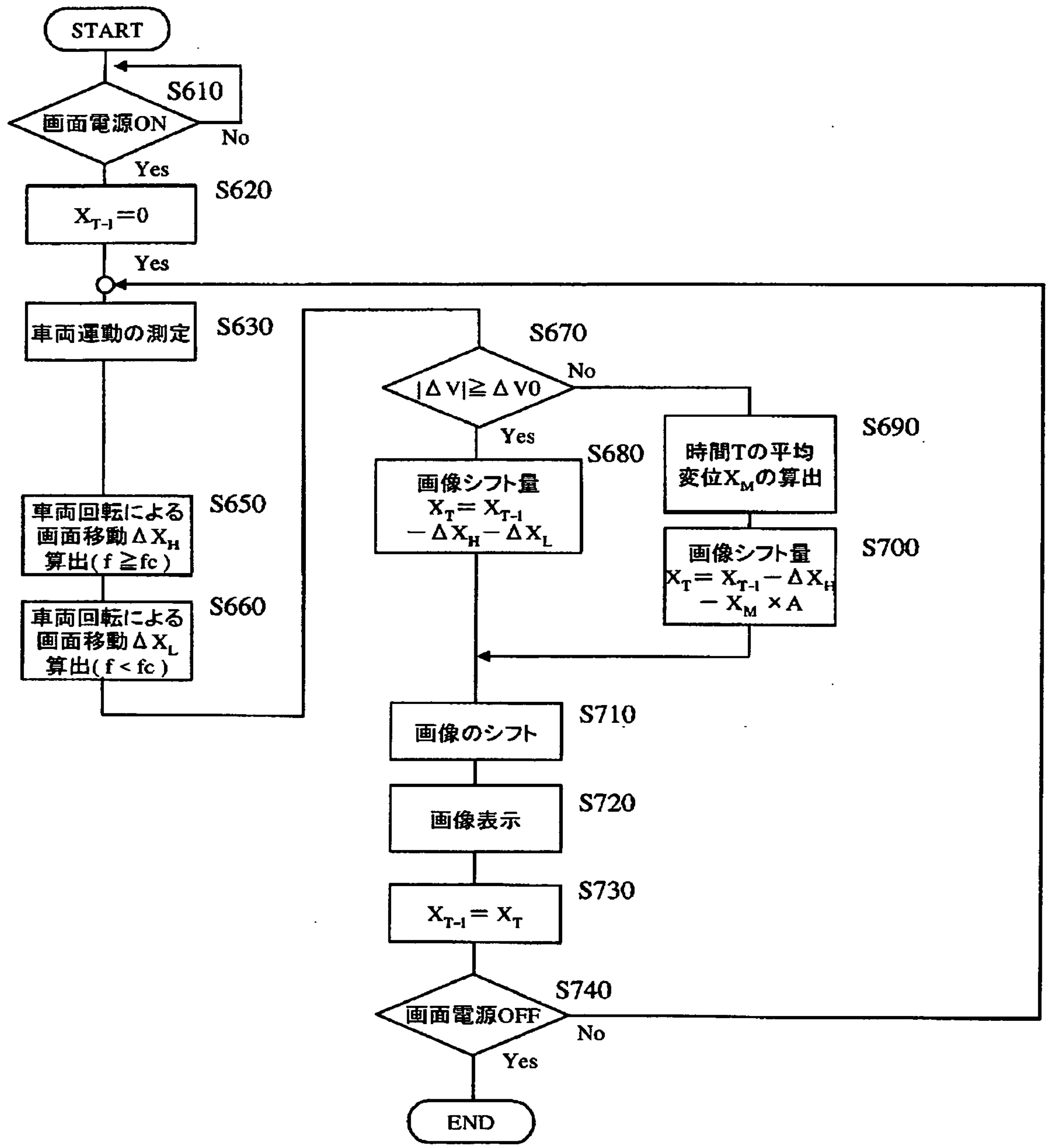
【図10】

	直前の表示位置X_{T-1}	$f \geqq fc$での画面位置変化量ΔX_H	$f < fc$での画面位置変化量ΔX_L	時間T間の平均変位X_M
定常走行時	○	○	×	○
加減速時	○	○	○	×

【図11】



【図12】



START
S610
画面電源ON
No
Yes
S620
$X_{T-1}=0$
Yes
S630
車両運動の測定
S650
車両回転による
画面移動ΔX_H
算出($f \geqq fc$)
S660
車両回転による
画面移動ΔX_L
算出($f < fc$)
S670
$|\Delta V| \geqq \Delta V0$
No
Yes
S680
画像シフト量
$X_T = X_{T-1}$
$-\Delta X_H - \Delta X_L$
S690
時間Tの平均
変位X_Mの算出
S700
画像シフト量
$X_T = X_{T-1} - \Delta X_H$
$- X_M \times A$
S710
画像のシフト
S720
画像表示
S730
$X_{T-1} = X_T$
S740
画面電源OFF
No
Yes
END